Argonne Pyroprocessing Proposal

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DOE FY2003 Congressional Budget Request Provided Guidance

- **"The Department will complete an *ANL-W Nuclear Technology Operations Plan* during FY2002 that will balance the needs of new research activities with the need to meet environmental commitments."**
- **Spent Fuel Pyroprocessing Research and Development FY2003 activities:**
  - **"Pyroprocessing will separate actinide (potential fuel) from uranium in spent fuel…"**
  - **Reduction of oxide fuel to metal for recycling by pyroprocessing.**
  - **Demonstration of the use of pyroprocessed fuel in reactors.**
  - **Qualification of the metal and ceramic waste forms.**
- **EBR-II Spent Nuclear Fuel will be processed in FY2003, at a rate consistent with the conduct of a parallel research program.**

Spent Fuel Pyroprocessing Utilizes Argonne's Expertise

- Chemical Technology Division develops electrorefining, oxide fuel reduction, waste processes and waste form development.
- Reactor Analysis and Engineering Division supports cathode processing, mass tracking and safety analyses.
- Technology Development Division supports mass balances and process model upgrades.
- ANL-W divisions and facilities implement processes and process spent nuclear fuel.
  - Fuel Conditioning Facility
  - Hot Fuel Examination Facility
  - Analytical Laboratory

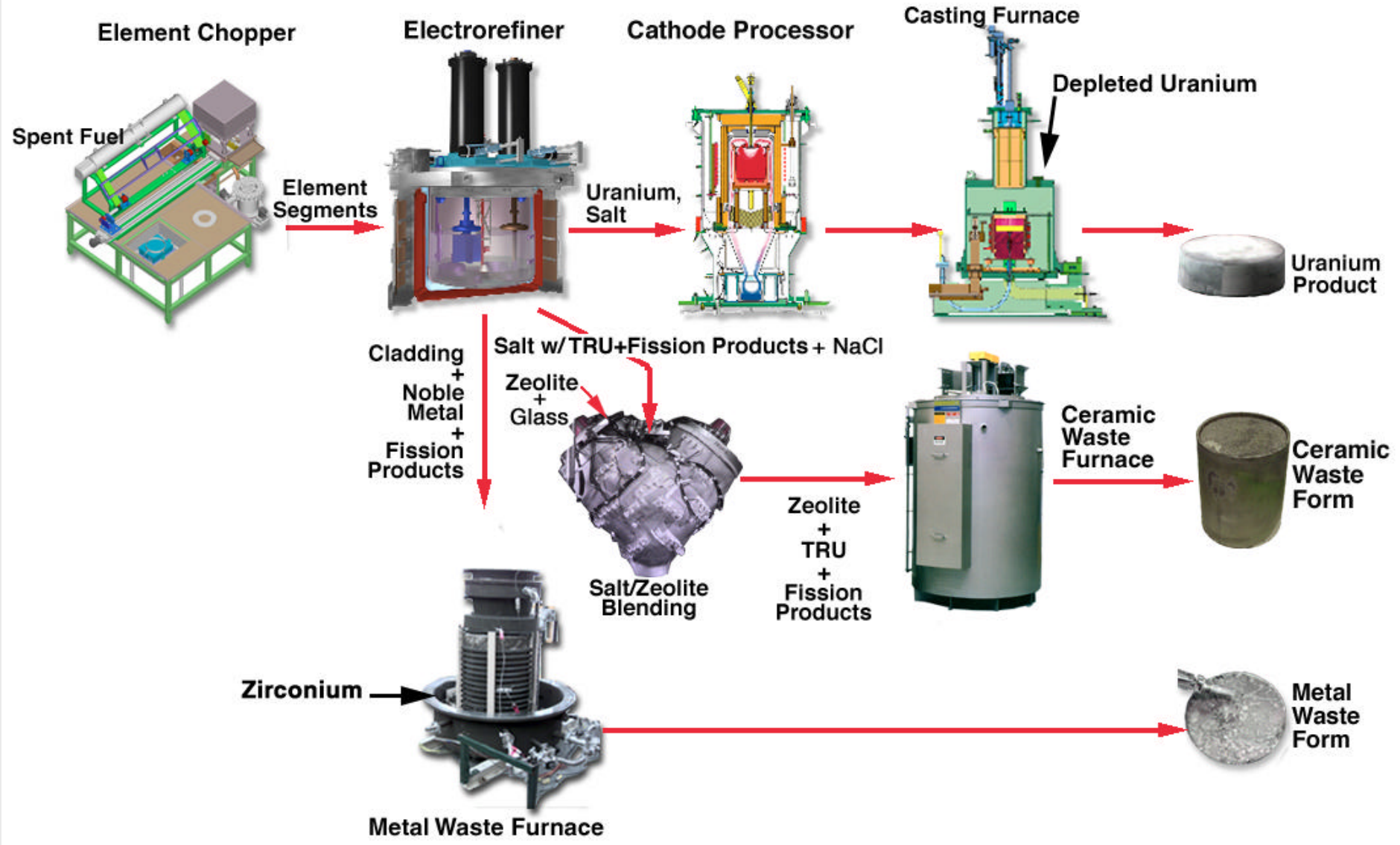
EBR-II Spent Fuel Treatment Program History

- Argonne started the development in the laboratory in the early 1980s.
- Technology demonstration was completed between June 1996 and August 1999.
- National Academy of Science (NAS) Subcommittee issued their final evaluation report in April 2000.
- Environmental Impact Statement and Record of Decision was completed September 2000.
- Spent Fuel Treatment Implementation Plan approved by ANL and DOE October 2000.
- Routine operations with EBR-II fuel were resumed in September 2000.

NAS Final Report Supported Electrometallurgical Technology

- **Finding: The committee finds that ANL has met all of the criteria developed for judging the success of its electrometallurgical demonstration project.**
- **Finding: The committee finds no technical barriers to the use of electrometallurgical technology to process the remainder of the EBR-II fuel.**
- **Recommendation: If the DOE wants an additional option besides PUREX for treating uranium oxide spent nuclear fuel, it should seriously consider continued development and implementation of the lithium reduction step as a head-end process to EMT.**

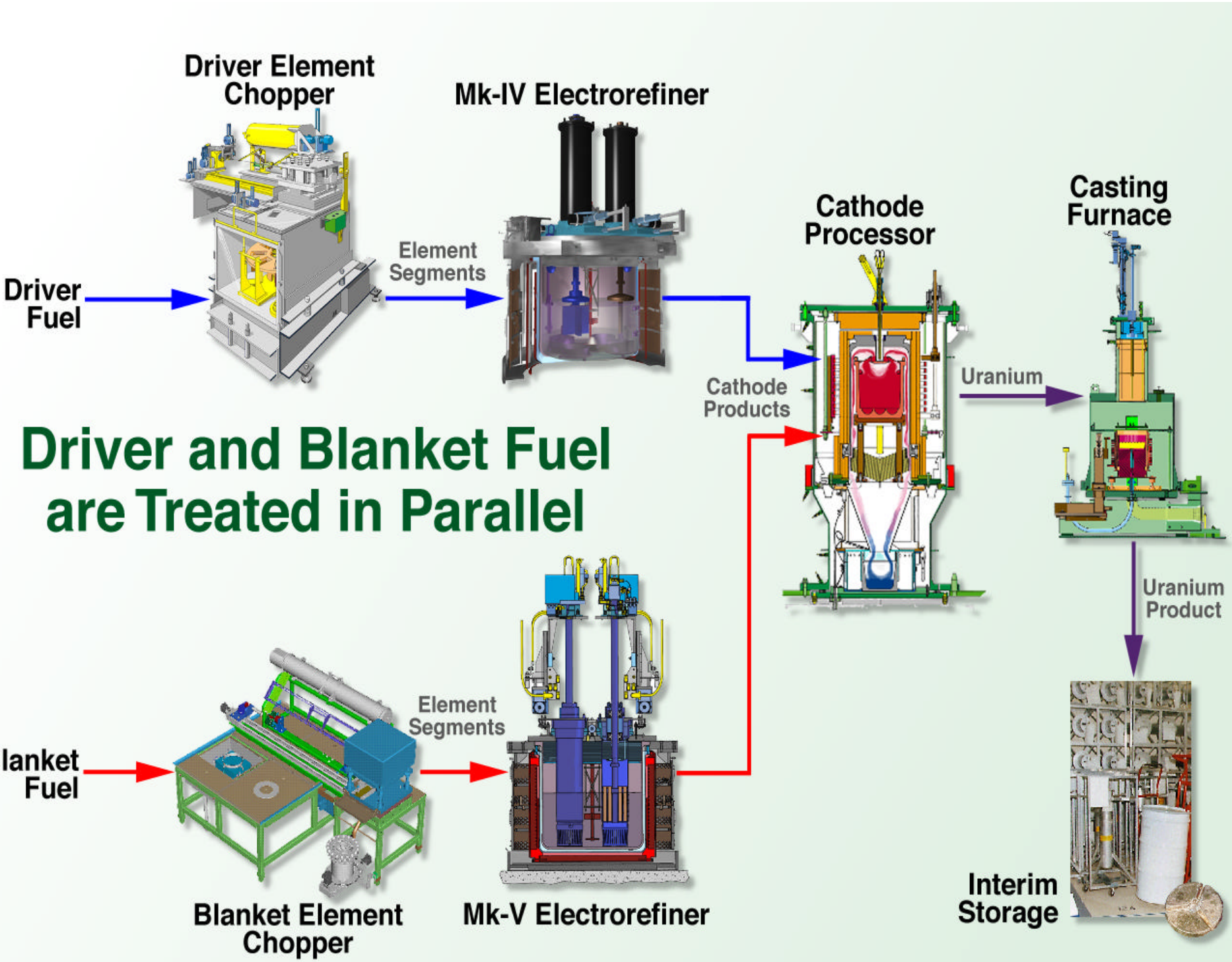
EBR-II Spent Fuel Treatment Flowsheet



Sodium-Bonded Fuel for Treatment

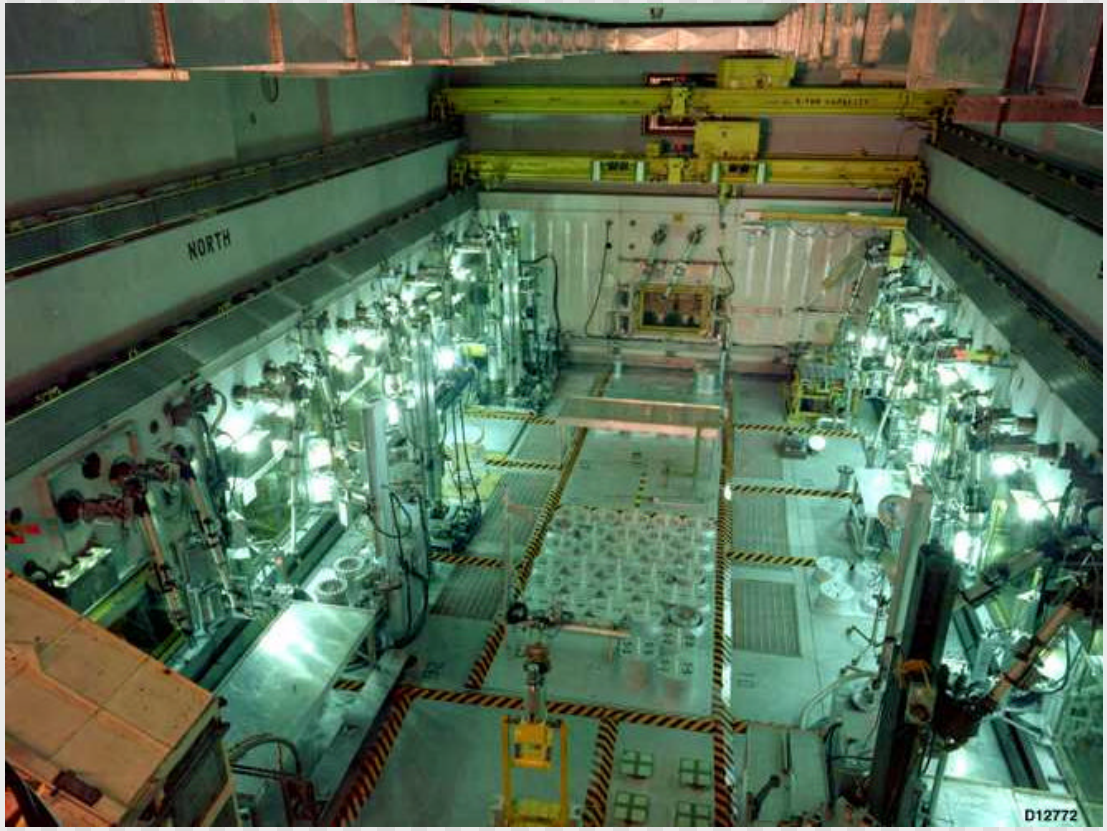
Fuel Type	EBR-II Fuel Treated (kg)	EBR-II Fuel Remaining at ANL-West (kg)	EBR-II Driver at INTEC (kg)	FFTF Fuel (kg)	Total (kg)
Driver Fuel	424	676	2,000	250	3,350
Blanket Fuel	1,810	20,590	0	0	22,400
Total	2,234	21,266	2,000	250	25,750*

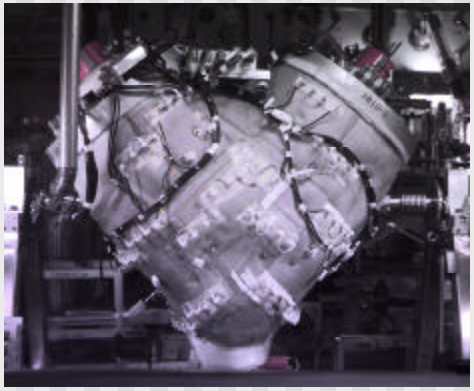
*An additional 34,200 kgs Fermi-1 blanket fuel is owned by DOE.


Driver Element Chopper
Mk-IV Electrorefiner
Driver Fuel
Element Segments
Cathode Processor
Casting Furnace
Cathode Products
Uranium
Driver and Blanket Fuel are Treated in Parallel
Uranium Product
Blanket Fuel
Element Segments
Blanket Element Chopper
Mk-V Electrorefiner
Interim Storage

Fuel Conditioning Facility for Spent Nuclear Fuel Treatment

Waste Processes Operate in Hot Fuel Examination Facility (HFEF)

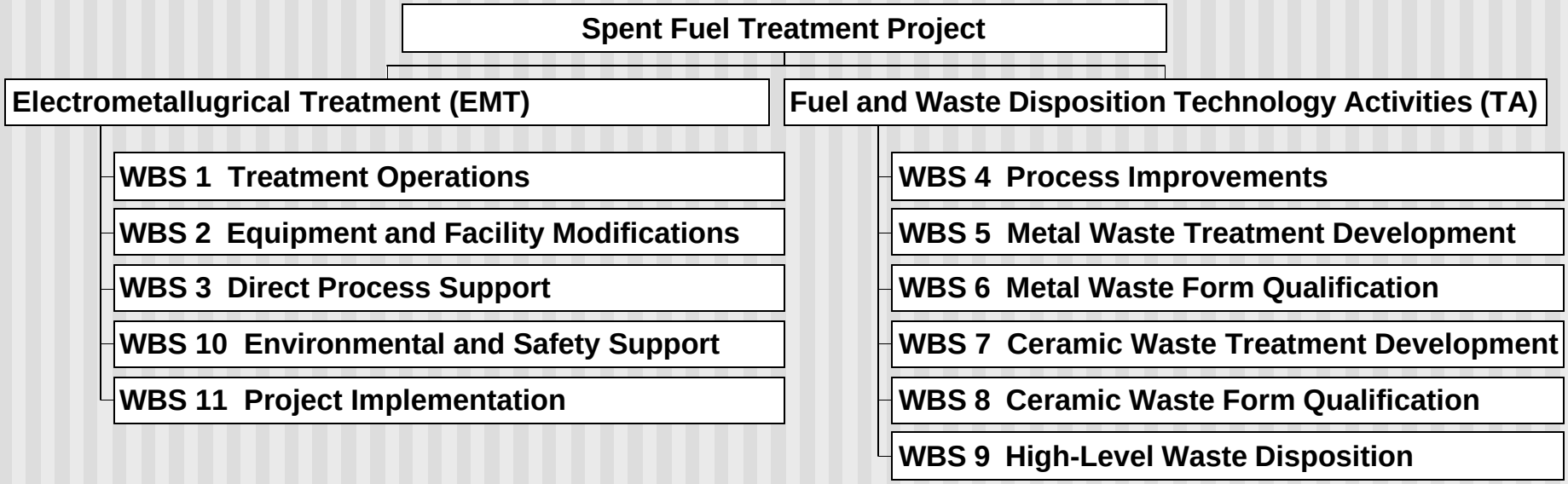




Present Process Capabilities

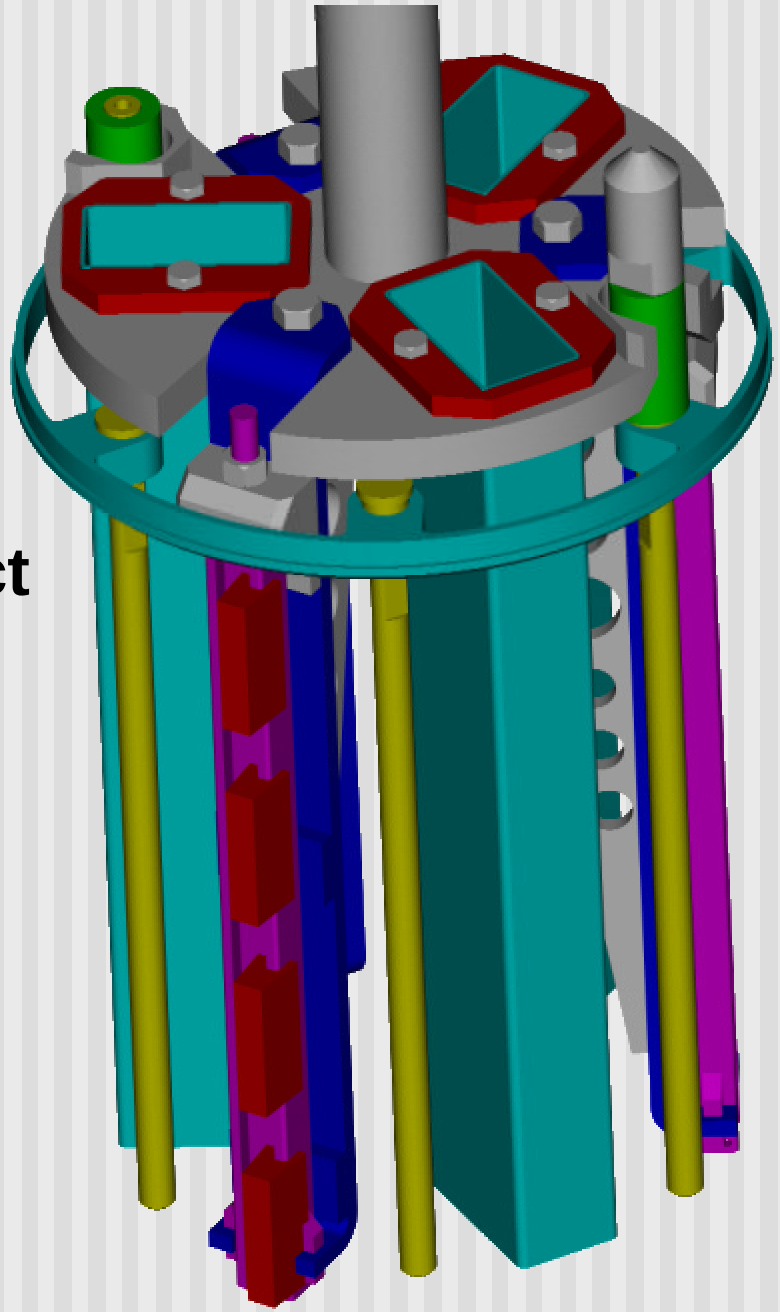
- With the present equipment, 2200 kg of heavy metal can be processed per year.
- The required operating condition for this throughput is
  - 24 hours per day, 7 days per week, 10.5 months per year.
- Process development and improvement activities are providing the necessary new equipment and process changes to increase capacity to 5,000 kg per year.

Spent Fuel Treatment Work Breakdown Structure (WBS)



Electrorefining Development Supports Existing Equipment

- Tests will focus on product fill rate and product morphology/density.
- Increased inter-basket spacing expected to increase product density.
- Electrically isolated stripper rods expected to increase efficiency.
- Compatible with existing electrorefiners.



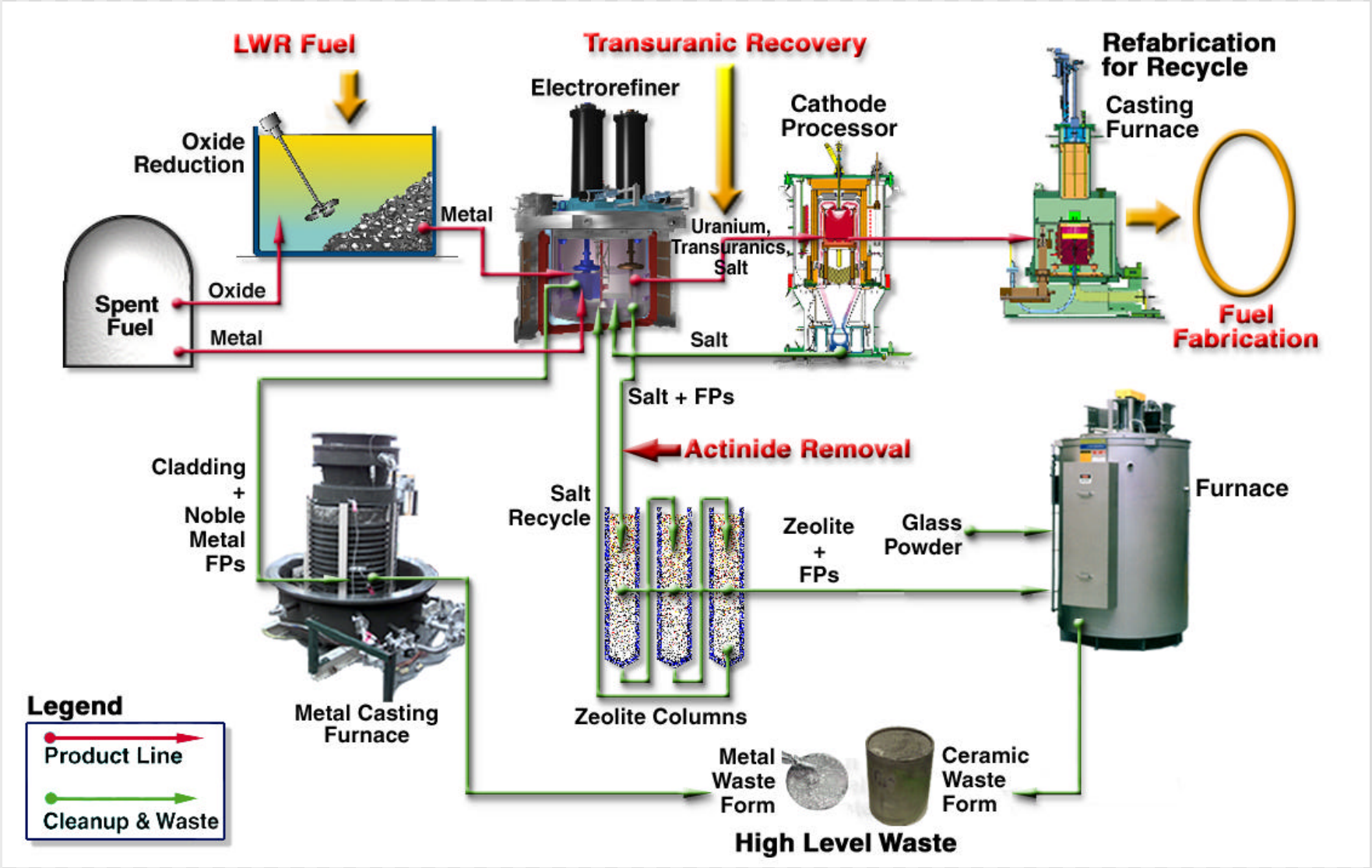
Uranium Chlorination Is Being Developed for Mark-V Oxidant Production

New Metal Waste Furnace Produces Ingots Ready for Repository

Ceramic Waste Form Production Testing

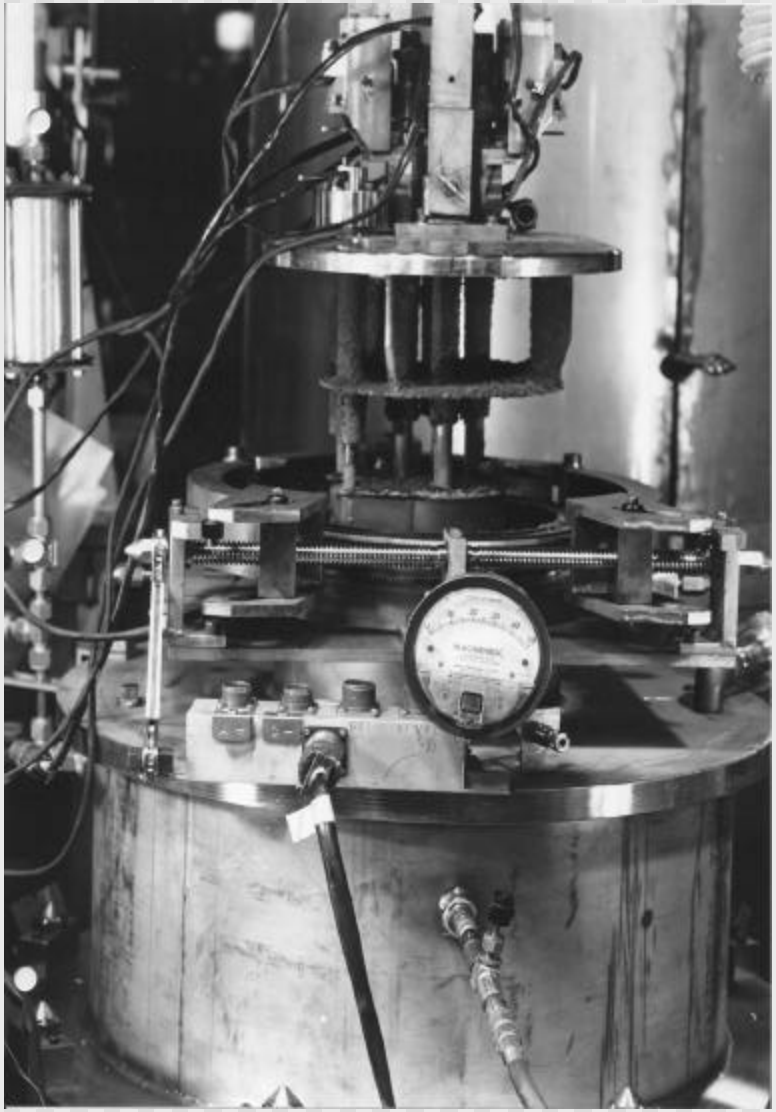
- Pressureless consolidation is now the reference production method.
- Production-scale samples have been produced up to 100 kgs.
- Irradiated ceramic samples are the same as laboratory samples.

Pyroprocess Demonstration Gaps

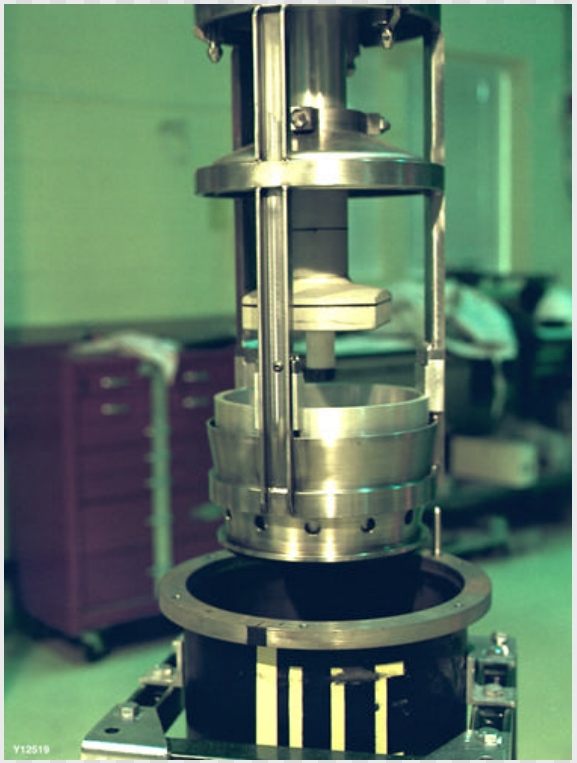


Laboratory-Scale Capabilities for Pyroprocessing Research with Spent Nuclear Fuel

- The Hot Fuel Dissolution Apparatus (HFDA) is a small-scale electrochemical cell operating in the Hot Fuels Examination Facility (HFEF).
- The chemistry of recovering all actinides and reduction of spent oxide fuel can be tested.



FCF Liquid Cadmium Cathode for Engineering-Scale Testing



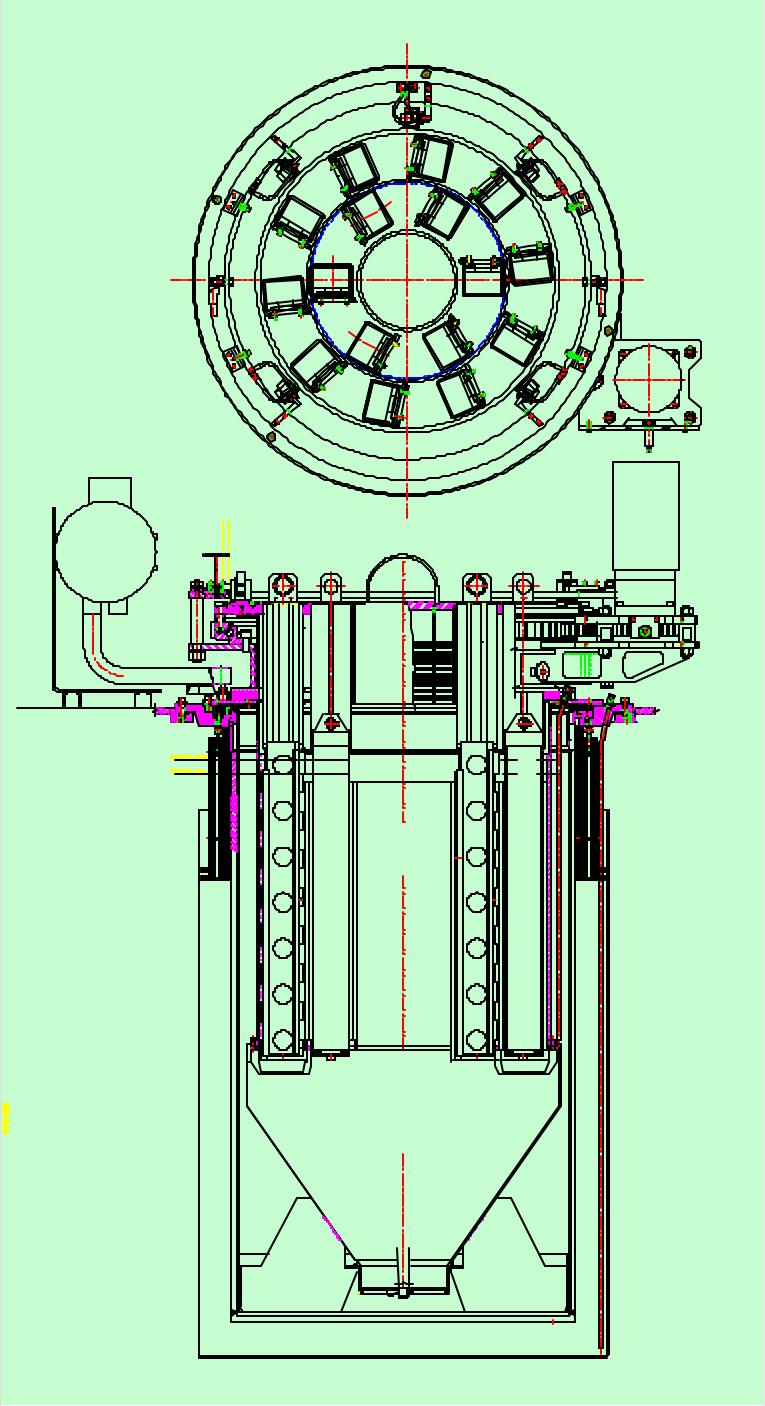
- Mock-up testing of the equipment was performed at FCF prior to the termination of the IFR program in 1994.
- Two LCCs have been in storage since that time.
- They can operate in both the Mark-IV and Mark-V electrorefiners.

Present Pyrochemical Operations Provide Good Basis for Future Research and Development

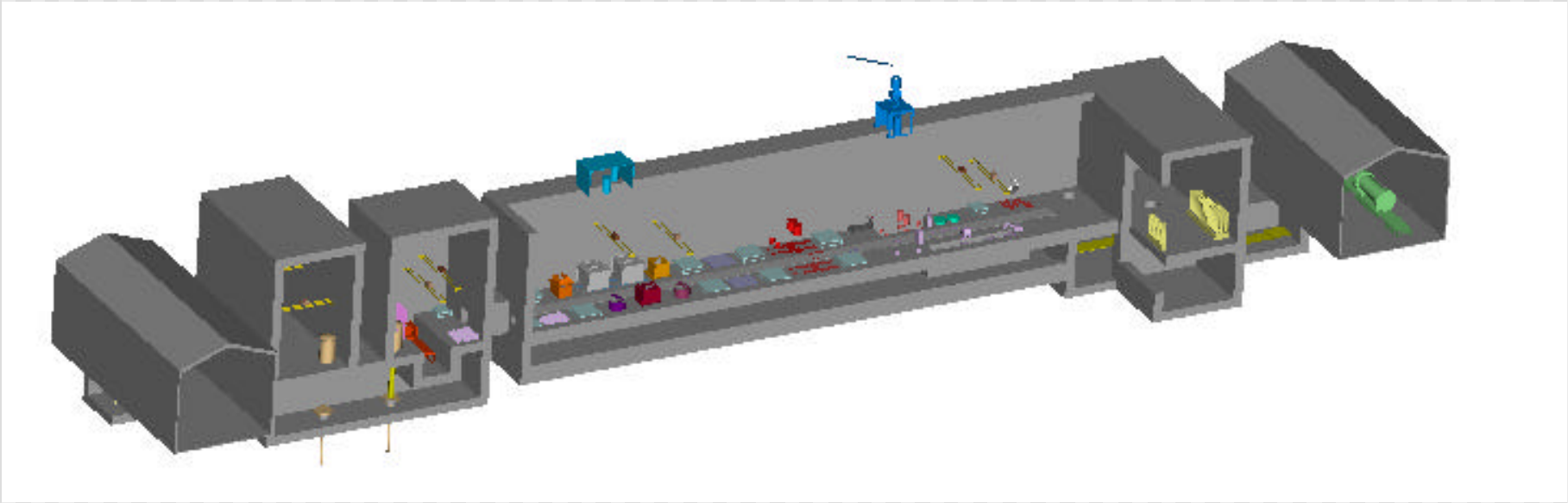
- Mk-V Electrorefiner provides adequate quantities of plutonium for testing recovery methods.
- Previous experience with remote EBR-II fuel fabrication equipment aids future equipment designs.
- Our crucible materials of construction work supports elimination of actinides from waste streams.
- Mass tracking system and integrated process models provide foundation for integrated safeguards technologies.
- Engineering-scale oxide reduction facilities are available for renewed process development at Argonne-East.

Electrorefining Rates Can Be Increased with New Designs

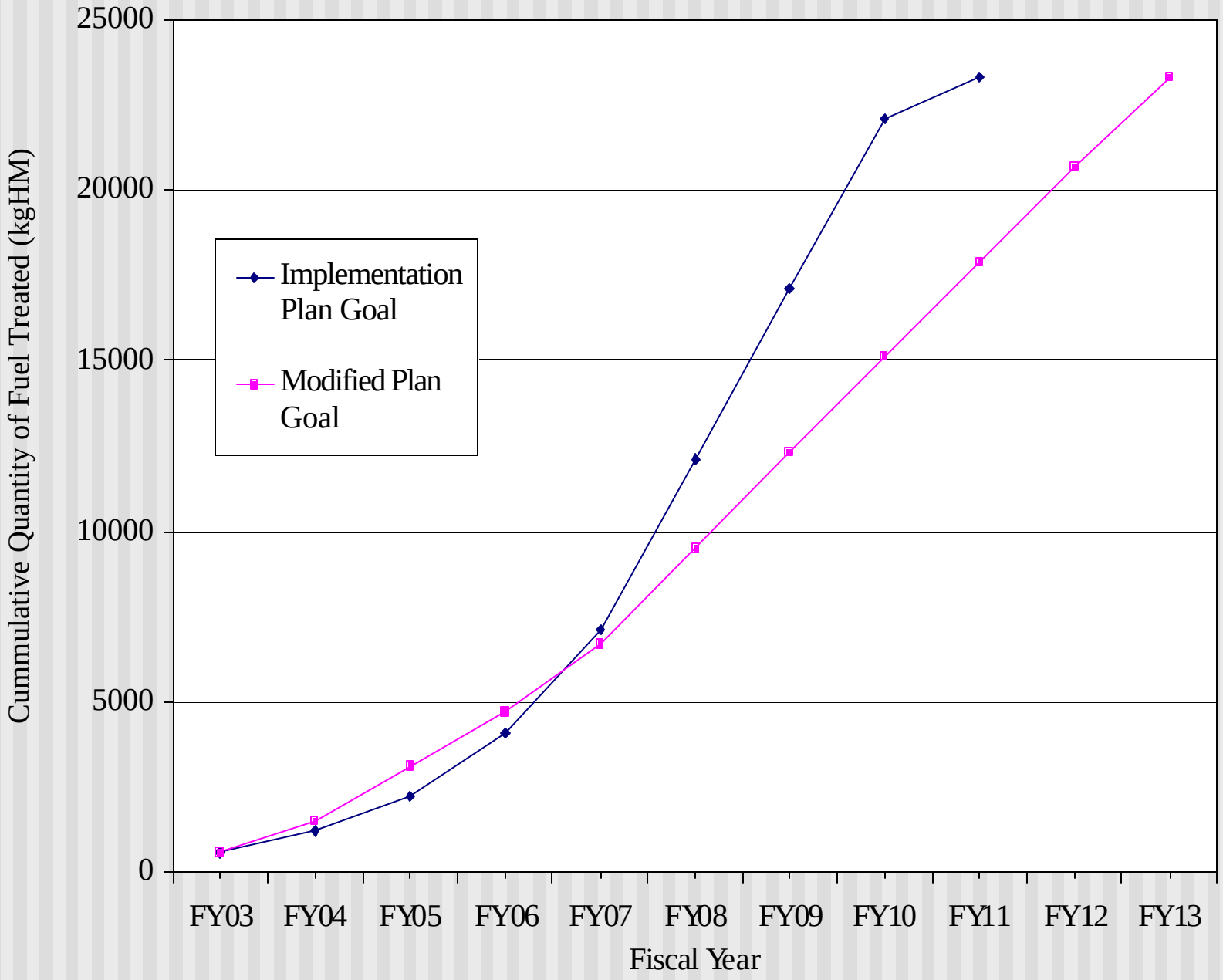
- Peripherally driven anode
- Product is removed up through the center of the electrorefiner
- Initial model will be a one-channel unit
- Scalable to multi-channel unit
- 4-ft diameter unit can hold as much as 500 kg of chopped fuel



Pyroprocessing Research and Development Supports Feasibility Design of 100 MTHM Per Year Facility



Modified EBR-II Treatment



Proposed Spent Fuel Treatment Milestones

Spent Fuel Treatment Milestones	Completion Date
Establish INTEC Agreement for EBR-II Fuel Receipts	May 2003
Complete Treatment of 540 kg Fuel in FY03	September 2003
Complete CP Capacity Upgrades	January 2004
Complete Treatment of 780 kg Fuel in FY04	September 2004
Complete Mark V ACM Upgrades	April 2005
Start Metal Waste Process Operations	May 2005
Complete Treatment of 1300 kg Fuel in FY05	September 2005
Complete Treatment of 1800 kg Fuel in FY06	September 2006
Start Ceramic Waste Process Operations	January 2007

Proposed Pyroprocessing RD&D Milestones

Pyroprocessing RD&D Milestones	Completion Date
Complete Laboratory-scale Proof of Principle TRU Recovery by Electrolytic Methods	August 2003
Demonstrate Reduction of Spent Oxide Fuel	September 2003
Complete Commercial Demonstration Facility Feasibility Report	September 2003
Select Oxide Reduction Engineering-scale Cell Design	December 2003
Demonstrate Engineering-scale Electrochemical TRU Recovery	March 2004
Demonstrate High-throughput Electrorefining Concept	December 2004
Start Engineering-scale Oxide Reduction Operations	January 2005
Demonstrate Kg-size TRU Free Ceramic Waste	September 2005
Select Reference High-level Waste Forms	March 2006
Select Reference TRU Recovery Process	September 2006

Proposed ANL Funding ($millions) for Spent Fuel Pyroprocessing Program

	FY02	FY03	FY04	FY05	FY06
SFT Electrometallurgical	$15.5	$20.8	$24.0	$28.0	$29.0
SFT Technology Activities	$7.2	$7.5	$7.5	$6.0	$5.0
SFT Subtotal	**$22.7**	**$28.3**	**$31.5**	**$34.0**	**$34.0**
Pyroprocessing RD&D	**$8.7**	**$15.0**	**$17.5**	**$20.0**	**$22.0**
Transmutation Studies	**$6.5**	**$4.0**	**$3.0**	**$2.0**	**$2.0**
ANL SFP/T Total	**$37.9**	**$47.3**	**$52.0**	**$56.0**	**$58.0**